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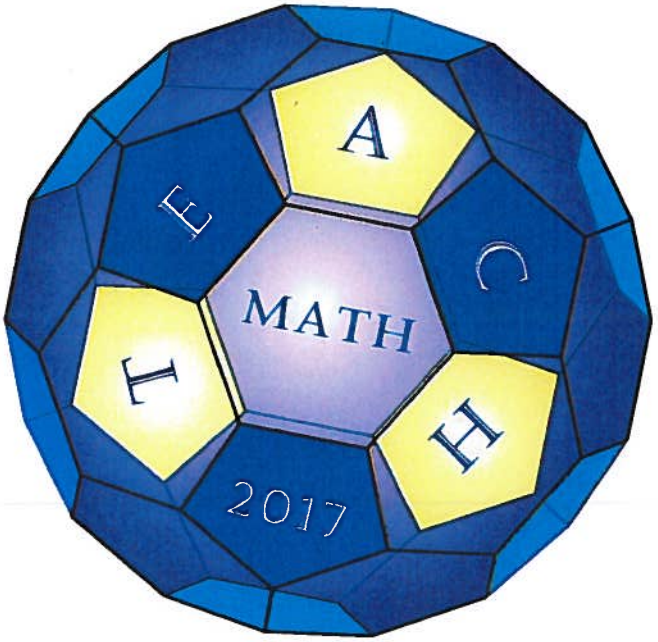

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The study approaches of university students in a calculus class

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Abstract. 191 US first-year university students got the ASSIST (Approaches and Study Skills Inventory for Students) questionnaire as part of a mid-term course evaluation. The students were not in any science, engineering, or mathematics study programme but took a calculus course to satisfy the university breadth requirement for mathematics. The strategic approach was the most commonly used. There was a positive correlation between the deep and the strategic approaches and a negative correlation between the surface and the strategic approaches. There was no correlation between the deep and the surface approaches except a negative correlation between the sub-scales Lack of purpose and Interest in ideas. The surface approach had a negative effect, while the strategic approach had a positive effect on learning outcome.

Keywords: learning approaches, study approaches, deep approach, strategic approach, surface approach, calculus, university students, learning outcome

1. Introduction

The focus of this paper is the group of university students who are required to study mathematics, for instance calculus, even though they do not aim at studying mathematics, engineering, or science. Many students enrol in university programmes not wishing to have mathematics courses as a compulsory part of their study programme (Guzman et al. 1998). These students often have difficulties understanding the mathematical concepts (Morgan, 1990). Jukić and Dahl (2012, 2014) investigated the long-term retention of core calculus concepts by science and engineering students and found that mostly the students had a fragile knowledge base even though they had later in their study programme encountered calculus in other courses. Abramovich and Grinshpan (2008) furthermore argue for special

teaching of mathematics to non-mathematics students in engineering, business, and life sciences. Hence, more research is needed on how different kinds of students approach and learn university mathematics such as calculus.

2. Theoretical background

2.1. Deep, surface, and strategic study approaches

Generally a student's approach to studying and learning is a collection of the student's intentions and strategies which to some extent is a reflection of the context and the demands the student meets (Gadelrab, 2011). Biggs and Tang (2007), Biggs et al. (2001), Entwistle (1991), Ramsden (1979) and others argue that the study and learning approach has a crucial role in relation to the quality of learning. They describe several types of approaches. In the 'surface approach' the students use low cognitive level activities and processes such as rote learning even when higher level activities might be intended by the teacher. The students are here focused on reproducing the material, describing, performing algorithms, etc. The focus is not on creating personal meaning of the material but to avoid failure with minimal effort. Students with a 'deep approach' try to use the most appropriate cognitive activities and processes to handle the material such as focusing on the underlying meaning and learning is a pleasure for them. The students intend to understand, analyse, generalise, hypothesise, evaluate, etc. A third approach, the 'strategic', was described by researchers later than the two other approaches. This is a well-organised surface approach focused on what is required in the examination. Students may here use both deep and surface approaches as they focus on both the content of the material and the mark. Their major intention is to achieve the highest mark possible using an organised study method.

The learning approach is a function of both the individual student's characteristics and the teaching style. It is to some extent a context-dependent response to how the student perceives the learning environment. Clouder (1998) argues that the pressure for knowledge acquisition within a finite time span make university students adopt strategic approaches. Previous studies have shown a relation between approaches to learning and the quality of learning. A deep approach is associated with high quality of student learning, but surface learning was related to poor learning outcomes (Gibbs, 1020; Biggs et al., 2001). However, Darlington (2011) discusses that a surface approach of for instance rote help fully understanding a theorem or a procedure. Cano and Berbén (2009) studied first-year university students in different science subjects but all enrolled in algebra and calculus courses. They found that performance goals (which correlates with surface learning approaches) correlates negatively with achievement. There is no correlation between mastery goals (which generally correlates with deep learning approaches) and achievement.

As stated above, the learning approaches of mathematics and non-mathematics students are different and in order to get deeper into researching the non-mathematics students' approaches, we need to discuss how to measure the learning approaches.

2.2. Measuring the approaches

One way to measure students' study and learning approaches is to use ASSIST (Approaches and Study Skills Inventory for Students) which is one of several questionnaires that have been validated in several contexts. ASSIST tests general study and learning approaches. It is based on the above mentioned three approaches whereas other questionnaires (e.g. that of Biggs et al., 2001) do not include the strategic approach. ASSIST has been developed over a period of time and some editions have been made to earlier versions. For instance the strategic approach has been broadened to include aspects of metacognition ('monitoring effectiveness') and the surface approach also emphasise ineffective studying ('lack of purpose') and was therefore renamed to Surface Apathetic Approach. The deep approach requires both holistic ways of thinking ('relating ideas') and serialist ('use of evidence'). The three approaches form three scales with subsequent sub-scales each related to central aspects for the approach. ASSIST has 52 items; four items for each sub-scale. Each item is a statement on a five-point Likert scale (5=Agree, 4=Agree somewhat, 3=Unsure, 2=Disagree somewhat, 1=Disagree) (Tait et al., 1998):

Deep Approach (D) with four sub-scales: 'Seeking meaning (SM)', 'Relating ideas (RI)', 'Use of evidence (UE)', 'Interest in ideas (II)'

Strategic Approach (S) with five sub-scales: 'Organised studying (OS)', 'Time management (TM)', 'Alertness to assessment demands (AA)', 'Achieving (AC)', 'Monitoring effectiveness (ME)'

Surface Apathetic Approach (A) with four sub-scales: 'Lack of purpose (LP)', 'Unrelated memorizing (UM)', 'Syllabus-boundness (SB)', 'Fear of failure (FF)'

'Alertness to assessment demands' (AA) was the last added sub-scale. 'Monitoring effectiveness' (ME) encompasses metacognition and self-regulation. It is argued that AA and ME are mainly applicable to graduate students (Gadelrab, 2011). ASSIST was used to answer the following questions:

3. Research questions

In relation to non-mathematics first-year university students who are required to take a mathematics class: What are their learning and studying approaches and how are these approaches related? How do they respond to the two sub-scales (AA, ME) more intended for graduate students? How do their approaches relate to their learning outcome?

4. Methodology

4.1. Selection of student cohort

The study took place in the autumn of 2011 at a private US university in top 10 of Times Higher Education Ranking of North American Universities 2011-12. The author was a visiting scholar. The university was chosen through purposive sampling (Robson, 2002) as the author needed a university where students not in science, technology, engineering, or mathematics (STEM) study programmes are nevertheless required to study mathematics. In many countries (including the author's), university students are only required to study calculus, if they enter into a STEM study programme. But it is debated if other student groups need calculus and if and how they are able to learn it. It is also frequently discussed how much mathematics, including calculus students should learn in high school. The study does not focus on high school pupils but since the study is about first year students, one can assume that it might give some indications of at least students in their last years of high school. A part of the study has been published in Dahl (2017) which focus on the results of solving calculus tasks.

The university offers two courses on introductory single variable calculus. They cover the same material but at different pace. Students are encouraged to take the slower one if they only need calculus to satisfy the university's disciplinary breadth requirement. The faster one is required for engineering, science, and economics study. This paper investigates the 191 students in the slower course. The students were divided into three cohorts for the lectures. The majority of the students had not taken the US Advanced Placement Calculus exam (high school level) or did not get a good score in it. There were two lecturers from the mathematics department and four tutors.

4.2. Use of ASSIST

ASSIST became part of the midterm course evaluation which was an online survey using google docs which the lectures were supposed to do anyway. The questions in the course evaluation where for instance: "How did you find the midterm?", "How well are you able to hear your lecturer?", "How many hours per week outside of lectures do you spend on the class?", "Do you have any specific comments for your lecturer?" etc. Adding the ASSIST items to the course evaluation was not only to accommodate the author, but the lectures also found the ASSIST items useful to get to know the students and discuss with them how to study.

Smaller changes were made to nine ASSIST items. Some changes were from British English to American English: i.e. "mark" to "grade" (S02, S28). Other changes specified that the statements were about studying calculus and not studying in general (D17, D26, D33, A51) for instance in D17 where "When I read an article or book..." was changed to "When I read a calculus book...". Some reformulations were also made (D23, S36, A38) for instance in D23 where "Often I find myself questioning things I hear in lectures of read in books", "questioning"

was changed to "pondering". A42 was not included: "I'm not really interested in this course, but I have to take it for other reasons". It did not fit well with the students' circumstances. The university's breadth requirement requires all students to take one mathematics class, whether or not they are interested in it. I.e. a student in this course could 'disagree' with the first part but would have to 'agree' with the last part. A42 belonged to the LP sub-scale, but this sub-scale included other items that investigated the students' interest in calculus, for instance A16: "There's not much of the work here that I find interesting or relevant".

5. Results and discussion

The data was analysed using SPSS. 87 of 191 students answered the questionnaire after the lecturers emailed several reminders. The response rate is thus 46 %. Curtin et al. (2000) argues that the exclusion of cases that require several reminders does often not have an effect. Nulty (2008) states that online surveys achieve lower response rates than paper surveys and typically the response rates do not get above 47 %. Furthermore, the class was going to have the online mid term course evaluation survey anyway and during an in-class survey not all students are present. Krosnick (1991) also found that neutral responses are more frequent in surveys done in-class than online due to 'satisficing' where respondents tend to chose the middle ground for fear of judgement, the pace, or distractions. SCCE (2011) argues that a 33 % response rate is adequate for large classes (200 students). Nulty (2008) however argues that even when the response rates suggested are achieved, extrapolation of results is still to be done with care as this does not in itself secure that the survey results are representative of the whole group.

5.1. Analysis of internal consistency (reliability)

Cronbach's alpha assesses the internal consistency and how the items are correlated with each other. The alphas were as follows: Deep Approach 0.888, Strategic Approach 0.904, and the Surface Apathetic Approach 0.809. Generally, $\alpha > 0.7$ is acceptable (Bland & Altman, 1997).

The r states the correlation between the item and the sum of the other items in the scale. If $r < 0.3$, one should consider to remove the item since it does not measure the same as the other items (de Vaus, 2002). The numbers for "α if deleted" (Table 1) estimates the scale alpha if the particular item is removed. If this number is higher than the scale alpha, one should consider removing the item to increase the internal consistency (Field, 2005). Even though ASSIST has been validated elsewhere, It was necessary to perform this analysis since changes have been made to some of the items and ASSIST is mixed with a course evaluation. Furthermore Gadelrab (2011) argues that ASSIST might not be consistent across different cultures and contexts. Different academic disciplines and contexts might also foster different student approaches. This might also be the case for this group of students required to take a mathematics class. Table 1 displays the six items where this number was higher than the scale alpha. No other item had $r < 0.3$.

Table 1. Analysis internal consistency of items that would give higher alpha if deleted.

Item	r	α if deleted
S27: I'm good at following up some of the readings suggested by lectures or tutors	0.328	0.905
S28: I keep in mind who is going to grade an assignment and what they're likely to be looking for	0.269	0.908
D26: I find that studying calculus can be quite exciting at times	0.266	0.893
A12: I tend to read very little beyond what is actually required to pass	0.133	0.819
A38: I gear my studying closely to just what seems to be required for assignments and exams	0.132	0.815
A51: I like to be told precisely what to do in assignments	0.143	0.812

Item S27 should however not be removed since alpha would only marginally increase and $r > 0.3$. The remaining five items are removed from the analysis. Although four of these five items were changed from the original ASSIST, one cannot conclude that these changes caused the low r. The five other items that were changed all had $r > 0.3$.

After removing these five items, the alphas became: 0.893 (Deep Approach), 0.908 (Strategic Approach), and 0.834 (Surface Apathetic Approach). An analysis then showed that A25 (I concentrate on learning just those bits of information I have to know to pass) had $r = 0.204$. Removing A25 changed the alpha to 0.841 with all $r > 0.3$. In all four A-items that were removed constitute the SB (syllabus-boundness) sub-scale.

S28 was the only item that was removed from the sub-scales of ME and AA. 'Alertness to assessment demands' (AA) and 'Monitoring effectiveness' (ME) are mainly applicable to graduate students (see above) and both ME and AA have a significant and strong positive correlation with the strategic scale. This indicates that the two sub-scales can be used for these first-year students, perhaps due to that it is difficult to get into the university where the study took place. Scale A finally consisted of 11 items, D had 15 items, and S had 19 items. Since some items are removed from the analysis, comparison with other uses of ASSIST is to be made cautiously.

5.2. Analysis of approaches

The mean score of each scale calculated; Surface Approach ($M = 66.11$, $SD = 12.15$), Deep Approach ($M = 47.65$, $SD = 10.25$), and Strategic Apathetic Approach ($M = 32.30$, $SD = 7.87$). In a survey of undergraduate mathematics students from University of Oxford (UK), the equivalent means were $M = 69.03$, $M = 58.69$, and $M = 45.94$ (Darlington, 2011). Although one cannot just compare the means due to slightly different versions of ASSIST, we see that both student

groups (from top universities) preferred the strategic approach, then the deep, and then the surface approach. Biggs et al. (2001) argues that the prevailing approach tells something about the quality of the teaching and that the presence of a surface approach is a signal that either the teaching or the assessment is not aligned since students have been allowed to adopt this approach. Following this line of arguments, the students in this study appear to meet requirements that usually do not allow them to adopt surface approaches even though they may not be interested in calculus. Table 1 gives an overview of how the three scales relate to each other.

Table 2. Correlation between the scales.

	r	p-value
Deep – Strategic	0.518	0.000
Apathetic/surface – Strategic	−0.261	0.034
Deep – Apathetic/surface	−0.009	0.944

There is a strong positive correlation between the deep and the strategic approaches and a rather strong negative correlation between the surface and the strategic approaches. The surface-deep relationship has r close to zero, but the p-value is close to one. To get deeper into the relationship between D and A, calculation of sub-scale correlations was done. The only significant relationship ($r = -0.249$, $p = 0.033$) was between LP (Lack of purpose) and II (Interest in ideas). Correlation does not imply causation. However the latter result might indicate that the more the students feel a lack of purpose (which the students in this study might indeed feel as mathematics is required), the less they are interested in the ideas in the course; or vice versa, the less they are interested in the ideas in the course, the more lack of purpose is experienced.

5.3. Analysis of relation to perceived achievement

The author were not allowed access to the students' marks, but one of the items at the course evaluation asked the following: "Please rate yourself objectively, based on the grades you have been obtaining. How well have you been doing so far?" The scale was 1–10.

Table 3. Correlation between the scales and the students' rating of own performance.

	r	p-value
Deep	0.077	0.521
Apathetic/surface	−0.584	0.000
Strategic	0.292	0.013

The surface approach strongly correlates negatively with the (perceived) learning outcome. This fits the result mentioned above where the mean of the surface approach was quite low. The students probably did not often adopt this strategy as it was not useful. The strategic approach quite strongly correlates with the

(perceived) learning outcome. The result for the deep approach is not significant. Gadelrab (2011) found a positive correlation between both the deep and the strategic approaches and academic success. He argues that many students combine focusing on understanding the material with achieving the highest possible marks. The students in this study do not appear to use such a combination.

6. Conclusions

There are eight main findings concerning the non-mathematics first-year university students who are required to study mathematics: (1) The students mainly adopt a strategic approach. (2) There is a positive correlation between the deep and the strategic approaches, (3) a negative correlation between the surface and the strategic approaches, (4) and no significant correlation between the surface and the deep approaches except between the sub-scales Lack of purpose and Interest in ideas that are negatively correlated. (5) The surface approach correlates negatively with the perceived learning outcome, (6) the strategic approach correlates positively with the perceived learning outcome, (7) there is no significant correlation between the deep approach and learning outcome. (8) The students have an alertness of assessment demands (AA) and are able to monitor effectiveness (ME) even though the students are not yet in graduate study. A limitation is that although an adequate response rate was achieved, one cannot be sure that the 46 % who answered the survey are representative of all the students in the class.

The findings 1–3, 5–6 are similar to findings by others (see above) which indicate that the students in this study to some extent behave like other students even though they are taking a course they would otherwise not have chosen. However, the analysis also showed that the deep approach was not much adopted and the deep approach did not positively correlate with the perceived learning outcome or negatively correlate with a surface approach – as seen elsewhere. The students thus mainly adopt a strategic approach and they find that they are successful using this approach even though their interest is low which is also related to that they feel lack of purpose. They have experienced that the surface approach is not useful in learning the material which to some extent might also be a reflection of how the course is being taught, i.e. the students cannot achieve success in this course by only using a surface approach.

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Universitetsstuderendes studiestrategier på et calculushold

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Abstrakt. 191 førsteårsstuderende fra USA fik ASSIST (Approaches and Study Skills Inventory for Students) spørgeskemaet som del af en midtvejsevaluering på et kursus. Ingen af de studerende læste til ingeniør eller var indskrevet på naturvidenskab eller matematik, men alle tog calculus for at opfylde universitetets krav om bredde i uddannelse, herunder matematik. Det var den strategiske fremgangsmåde som blev brugt oftest. Der var en positiv korrelation mellem den dybdegående og den strategiske fremgangsmåde og en negativ korrelation mellem den overfladiske og den strategiske fremgangsmåde. Der var ingen korrelation mellem den dybdegående og den strategiske fremgangsmåde på nær på under-skalaerne: 'Lack of purpose' og 'Interest in ideas'. Den overfladiske fremgangsmåde havde en negative effekt på læringsudbyttet, mens den strategiske fremgangsmåde have en positive effekt.

Søgeord: læringsstil, studiefremgangsmåde, dyb fremgangsmåde, strategisk fremgangsmåde, overfladisk fremgangsmåde, calculus, universitetsstuderende, læringsudbytte